Comparison of Fundamental Frequency Between Spanish and English in Heritage Speakers of Spanish

Research Thesis

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by

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1. Introduction

This study explores the fundamental frequency or general pitch (F0) of heritage speakers of Spanish (HSS) comparing the mean and range of a speaker's pitch in English versus Spanish. A heritage speaker of a language is someone who has learned a language at home that is different from the one used in the wider community (Valdés 2001). In the United States, heritage speakers learn a minority language such as Spanish or Arabic in the home and learn English through the education system, and they are bilingual to varying degrees. There is a growing population of heritage speakers, not only in the United States but globally. While there is a growing body of research on the phonology of HSS, the study of their prosody is fairly unresearched, and there is much to be discovered. It is important to study the speech patterns of heritage speakers because they are a diverse population of bilinguals who offer unique insight into the study of bilingualism within the field of linguistics.

1.1. Motivation of study

The author of this paper observed one of their friends, a HSS, speaking English and Spanish in different situations and thought they noticed a difference in pitch when speaking one language versus the other. This observation initiated the study, and the lack of prosodic research on HSS strengthened its value. Specifically, there are many studies comparing HSS to native Spanish speakers (NSS), while there is a limited amount of studies comparing the prosody of a heritage speaker's own two languages.

2. Literature Review

While François Grosjean does not specifically mention heritage speakers in his book *Bilingual* (2010), he does talk extensively about bilingual children and how bilingualism can vary

depending on age of onset and the environment the child grows up in. There are two types of language acquisition in bilingual children: simultaneous, where a child learns both languages at once, usually between birth and four years of age, and successive, where a child learns one language first and then another, usually from five years of age and older. In terms of simultaneous acquisition, the child might have some overlap in phonology and lexicon when acquiring the languages but is able to keep them separate in terms of morphology and syntax. Children rely on many cues, including phonetic and prosodic structures, to determine how one language is different from the other. Those who acquire their languages successively usually learn one language in the home and the other language in school or through the community, as opposed to learning one language from one parent or caregiver and another language from the other. The work of Lily Wong Fillmore (1976) is mentioned, who claims that successive bilinguals can use their first language as an aid in acquiring the other. Another study mentioned by Grosjean claims that age of acquisition, however, is not the most important factor for becoming bilingual; the child's need for each language, the amount and type of input the child receives, the role of the child's parents and education, and the attitudes towards bilingualism that the child experiences are more influential than the age of acquisition (Snow & Hoefnagel-Hohle 1978).

There is much research that has contributed to the study of the phonology of heritage speakers of Spanish. Some studies have looked into how the production of consonants may differ from native speakers (NSS) (Kim 2011; Amengual 2012; Boomershine 2014; Rao 2015; Henriksen 2015, O'Rourke & Potowski 2016), while some have examined vowel production (Willis 2005; Boomershine 2012; Ronquest 2012, 2013; Alvord and Rogers 2014), and others have investigated the prosody of HSS (Alvord 2006, 2010; Robles-Puente 2014; Colantoni, Cuza, and Mazzaro 2016; Kim 2015; Hoot 2012). Prosody is one of the least explored areas

regarding HSS' phonetics and phonology (Ronquest and Rao 2018), but the studies that have been conducted thus far have demonstrated that the prosody of HSS can differ significantly from that of NSS, specifically in terms of intonation, stress production, and rhythm.

Intonation is defined as the modifications in pitch that influence the interpretation of the meaning of an utterance (Hualde 2005). Pitch accents are mental representations of intonation and are composed of high and low tones. Pitch accents are important for distinguishing the type of utterance being made. For example, a certain pitch accent (and how it is organized in the production of an utterance) denotes a question, while another marks an enthusiastic statement (Ladd 2008, Pierrehumbert 1980). In a series of studies, Alvord (2006, 2010a, 2010b) looked at the pitch accents of three generations of Cuban bilinguals in Miami, the third generation of which were HSS. Peninsular Spanish has a final rise at the end of interrogative utterances, specifically absolute interrogatives or "yes/no questions," due to there being no other marker to distinguish this interrogative utterance from a declarative one, which is typically marked with a final fall. Whereas English and many other languages follow this pattern (Quilis 1993), Cuban Spanish does not, and has a final fall in absolute interrogatives as well as declaratives (Alvord 2010a; García Riverón 1996a, 1996b; Quilis 1981; Sosa 1999). It was found that for absolute question patterns, both the first and third generations favored a final fall in tone, while the second generation preferred a final rise. It is suggested that the preference of a final fall for the third generation, comprised of HSS, is motivated by pride for Cuban identity. As mentioned before, as Peninsular Spanish is known to have a final rise for absolute interrogatives, Cuban Spanish is unique in that it has a final fall. It's suggested that HSS may use this Cuban-style interrogative to feel more connected to their Cuban identity.

Another study (Robles-Puente 2014) compared two groups of HSS, one of which was made up of adults, either born in Los Angeles or emigrated from Mexico at a young age, and the

other which had adolescents who were born in Los Angeles to immigrant parents. While both groups produced many phonological similarities to NSS, who were the controls of the study, the second, younger group of HSS produced intonational trends that were closer to those of NSS. This study also looked into whether HSS' speech is stress-timed or syllable-timed. A stress-timed language has stressed units that are spoken in somewhat regular intervals and unstressed units are shortened to fit to the rhythm, where in a syllable-timed language all syllables take about the same amount of time to be spoken. They found that while adult HSS' speech reflected the pattern found in English (stress-timed), the younger generation of HSS preferred the pattern of the language being spoken. That is, they used a stress-timed structure when speaking English and a syllable-timed structure when speaking Spanish.

Even though this study and Alvord's series of studies suggest that the prosodic production of younger generations of HSS can closely resemble the production of NSS, there are other studies which show that this production can vary greatly. Henriksen (2012) compared HSS and NSS in the Chicago area and found that HSS produced a wider range of intonational patterns in terms of interrogatives and declaratives. They concluded that this phenomenon was due to the increased contact that HSS have between Spanish and English. Another study also found more variation in the intonation of question patterns used by HSS than used by NSS (Rao 2016). This study also gathered information on participants' current and past use of Spanish as well as demographic information on their parents and the participants themselves, and reasoned that the variation found in HSS' production was due to the unique types of input that were received.

Other studies suggest that while HSS' perception can seem closely related to that of NSS, their production can differ greatly. Kim's (2015) study compared both the perception and production of stress by HSS, NSS, and L2 learners in their 4th semester. Both HSS and NSS

showed accurate perception of penultimate versus final syllable stress, but as for their respective production of words with penultimate stress, HSS (as well as L2 learners) produced lengthened unstressed vowels which ultimately caused final stress where it did not originally exist. Overall, HSS' production can closely relate to that of NSS in some cases but can differ greatly due to extralinguistic factors or even linguistic factors that have not yet been closely and thoroughly studied.

While the study from Passoni et al. (2018) compared the pitch range of British English and Japanese bilinguals, the research question and methodology greatly influenced that of this study. The researchers examined whether bilinguals vary their pitch range due to the language being spoken. Additionally, they also looked into whether this variation had social value; that is, if a person's pitch varied due to their audience. Many studies mentioned in this paper focus on heritage speakers, however Passoni et al. used Japanese-native L2 learners of English for their study. The study used a reading task where the sex and formality (i.e. high school student vs. member of Royal Family) of the addressee were changed to determine if the pitch would change with it. The participants were asked to read the sentence given as if they were speaking to the addressee shown to them. Their recordings were analyzed in Praat, extracting the F0 maximum, minimum, and average for each utterance. They found that the participants spoke Japanese at a lower mean F0 than when they spoke English, which is contradictory to previous findings. They mentioned that one of the Japanese women participants made a negative remark about the way that Japanese women stereotypically speak the language, which is at a significantly high pitch according to a study from Loveday (1981). They claim that this could be reflected in her results, where her English had a much higher average pitch than her Japanese, as her opinion about Japanese women speech may not carry over to English women speech.

Colantoni et al. (2016) is a study on task-related effects in the prosody of Spanish speakers, which heavily influenced the methodology of this study. The authors of this paper proposed that language use had an influence on the Spanish prosody of the speaker, specifically the intonation used in broad-focus declaratives, and compared the speech of long-term Mexican immigrants (LTIs) to that of heritage speakers in the United States. They had both groups complete a reading task and a semi-spontaneous speech exercise. For both tasks, all utterances that were broad-focus declaratives were extracted and words with ultimate and penultimate stress were analyzed. The LTIs had consistent results for both tasks, which is similar to the results found for monolingual Mexican Spanish speakers in another study (Face 2003). However, while the LTIs and HSS produced similar results in the narrative task, the HSS behaved differently from the LTIs in the reading task. HSS produced more self-corrections, mispronunciations, and intonational phrases per statement than the LTIs. It is suggested that these differences are due to the fact that even though the HSS were pursuing university-level Spanish education, they had been educated in English and were more used to reading in English than in Spanish.

In this study, the following question is posed: Do heritage speakers of Spanish present differences in their pitch in English vs. Spanish?

- As observed in their F0 minimum and maximum?
- As observed in their mean F0?

Studying the production of HSS in particular is very useful because they are a growing, global population of bilinguals. While there are many studies comparing the Spanish phonology of heritage speakers to native speakers, there is a shortage of studies on prosody, and as of now there is not as much information comparing a heritage speaker's own two languages. It is relevant to pursue these types of studies to further understand how languages influence each

other in the mind of a bilingual person and in what ways the languages remain separate. Exploring the prosody of HSS, specifically comparing the fundamental frequency of their languages through the F0 mean and range, will contribute to the study of bilingualism in this way by indicating whether prosody of one language is influenced by the other or if they remain separate and distinct.

3. Methodology

3.1 Materials

The experiment consisted of two parts: an English section and a Spanish section. The English section had a language survey and a contextualized image description task. The language survey was the Bilingual Language Profile, which was borrowed from the linguistics professor Dr. David Birdsong from the Center for Open Educational Resources and Language Learning (COERLL) at the University of Texas at Austin. It measures a person's dominance between two languages, in this case English and Spanish, by giving a dominance score based on their language history, use, proficiency, and attitudes. The score is on a continuum where positive 218 would show complete dominance in English, -218 would show complete dominance in Spanish, and a score closer to 0 indicates "balanced" bilingualism, where one language doesn't clearly dominate the other. Dominance does not refer to proficiency explicitly, but indicates how one language is known, used, and perceived compared to the other. The BLP has been used in various studies with heritage speakers to measure their language dominance (Kim 2016; Zyzik 2016; Amengual 2018; Bondarenko 2018; Kim 2018).

The English image description task asked the participant to observe a family tree and describe aloud the relationships shown. There were 20 relationships to describe, with three

practice slides to get used to the format of the experiment. For each slide, participants produce the same type of sentence where only the names and the family relationships change but the overall syntax remains the same. The names given to the family members were those that are common in English-speaking cultures and that avoid voiceless sounds, since these sounds are not produced with vocal fold vibration and therefore do not display pitch. **Figure 1** includes a sample slide. In this case, participants were expected to produce sentences where they would describe the relationship between the two people pictured at the bottom of the screen using the sentence structure and the family tree given. For this slide, the expected utterance was “Olivia is Emily’s mother” or “Olivia is Emily’s mom.”

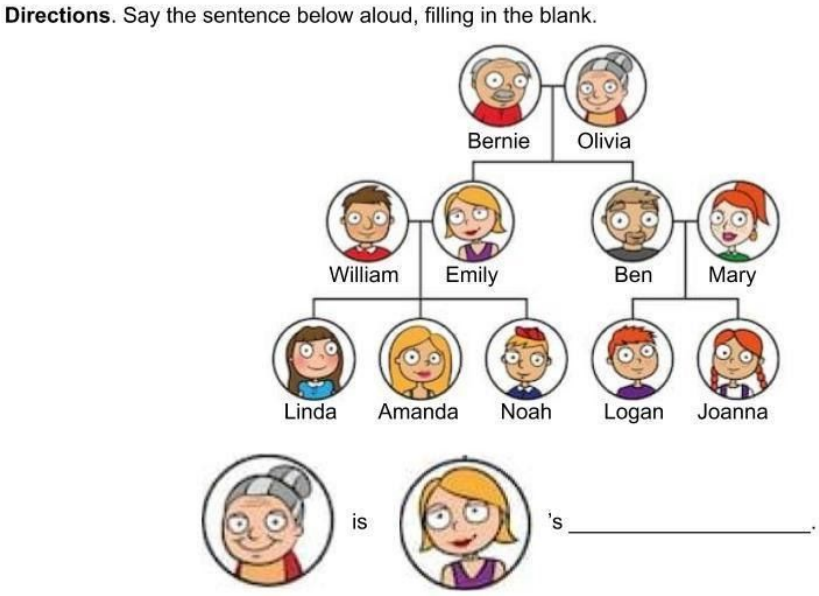

Figure 1: Example of English image description task.

After the English portion, the Spanish portion began with a short interview in Spanish which was conducted without being recorded. This questionnaire, which was created by the researcher, was used to gather further information about the participants’ language history, specifically the origin of their accent or dialect. It was also used as a buffer between the English

and Spanish image description tasks so that participants would change their language mode from English to Spanish. The interview was conducted orally, with the interviewer taking notes about the participants' responses throughout. The interview consisted of questions relating to where the participants' Spanish might come from or what it might be influenced by (location, friends, family, etc.). Some questions included "¿Qué idioma(s) habla tu padre/madre generalmente? (What languages does your father/mother speak in general?)," "¿De qué país(es) hispanohablante(s) proviene la familia de tu padre/madre? (Which Spanish-speaking countries does your father's/mother's family come from?)," and "¿De dónde crees que viene tu acento? ¿Un país, un ciudad? ¿Porqué lo piensas? (Where do you think your accent comes from? A country, a city? Why do you think that?)."

The second image description task followed the structure of the first, asking the participants to describe in Spanish the relationships between members of a family using a given family tree. There were three practice slides to get used to the format, and then 20 test slides. The pictures were changed, so that they weren't associated with the English language task, as well as the names to reflect those that are common in Spanish-speaking cultures. The names still did not include voiceless sounds to help avoid sounds that do not display pitch. **Figure 2** includes a sample slide. The participants were expected to describe the relationship between the two people at the bottom of the screen using the sentence structure given, as in the English image description task. For this slide, the expected utterance was "Gabriela es la prima de Manuel (Gabriela is Manuel's cousin)."

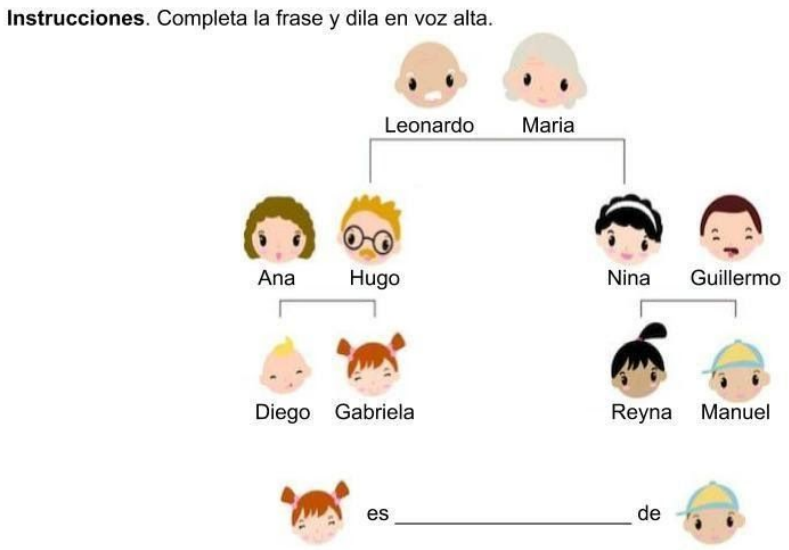

Figure 2: Example of the Spanish image description task.

3.2 Participants

Five heritage speakers of Spanish were recruited for this study. All participants currently live in central Ohio in the United States and are between the ages of 20-26. There are four women and one man. Each participant has had at least some experience with college. While all started learning Spanish at birth, the age at which they each started learning English ranged from birth from 8 years old. The parents of all the participants live in the United States. Four of the five participants have extended family in various regions of Mexico, with one participant having family in the Dominican Republic. Three of the participants had parents who both spoke Spanish, while all of them had at least one Spanish-speaking parent. Two of the participants lived in Mexico and moved to the U.S. at a young age (Age 3 for participant 2 and age 8 for participant 5). Four of the participants have made short visits, ranging from a few days to a few weeks, to Spanish-speaking countries for a variety of reasons (to visit family, to study abroad, for vacation, etc.) but have not lived in a Spanish-speaking country for an extended period of

time, excluding the two participants mentioned before who were born abroad. Three of the participants believe their Spanish dialect comes from Mexico, two of which specified either a Central (participant 5) or Northern (participant 2) Mexican dialect. Participant 3 believes their accent is influenced by their father's Dominican dialect, as well as their Spanish-speaking peers here in the US. **Table 1** shows the information laid out for each participant.

Table 1: Participant Information

	Age	**Sex**	**Education**	**Age at which you started learning English**	**Age at which you started learning Spanish**
Participant 1	22	F	Some college	Since birth	Since birth
Participant 2	26	F	Masters	3	Since birth
Participant 3	20	F	Some college	5	Since birth
Participant 4	23	F	Some graduate school	3	Since birth
Participant 5	23	M	Some college	8	Since birth

Table 1: Participant Information, *continued*

	Spanish-speaking country of residence for extended family	**# of Spanish-speaking parents**	**Spanish-speaking countries**	**Dialect**
Participant 1	Mexico	1	Visited Mexico	From mother and extended family
Participant 2	Mexico	2	Lived in Mexico; visited Mexico and Spain	From extended family and both parents
Participant 3	DR and Lebanon	1	Visited DR and PR	From father and community in US
Participant 4	Mexico	2	Visited Mexico and Spain	From both parents

Participant 5	Mexico	2	Lived in Mexico	From extended family and both parents

3.3 Recordings

All audio was recorded using the program Audacity and a Plantronics DSP head-mounted microphone, and was annotated to a TextGrid with Praat. All audio was measured in Hertz. The recordings were carried out in a linguistics office at The Ohio State University. Due to the researcher's limited knowledge of Spanish, a bilingual interviewer was designated to execute the entirety of the experiment, including giving instructions and answering questions that the participant might have. The researcher focused on the background work, including progressing through the slides and ensuring that all the equipment was recording effectively. The researcher refrained from speaking during the experiment to ensure that the participant only received input from the interviewer, as input from multiple sources with varying F0s might have an effect on the F0 of the participant.

3.4 Data Analysis

3.4.1 Bilingual Language Profile

The Bilingual Language Profile automatically calculates a dominance score that ranges from +218, representing complete dominance in English, to -218, representing complete dominance in Spanish. The participants' dominance scores ranged from -1.444 to +77.74, with an average of +29.64. Below is a table that shows each participant's individual score.

Table 2: Dominance Scores

Participant 1	Participant 2	Participant 3	Participant 4	Participant 5

77.74	48.038	7.462	16.44	-1.444

The dominance scores correlate to information given both in the BLP and in the Spanish-language survey. Participant 1's score could be influenced by only having one Spanish-speaking parent. While participant 3 also only had one Spanish-speaking parent, they reported growing up in a Spanish-speaking community in the U.S., while participant 1 did not report having a similar situation. Participant 1 also reported using Spanish only 10% with friends, while English was reported at 90%. Participant 5 was born and raised in Mexico for eight years before moving to the U.S., which included having three years of formal education in Spanish. Participants 3 and 4 also had some formal education in Spanish, both for nine years. Neither Participant 1 nor 2 had any formal education in Spanish. Participant 5 was the only one to report an exclusively Spanish-speaking family, having spent zero years in an English-speaking family, where every other participant reported having at least some family with whom they spoke English. Overall, Participant 1's lack of Spanish-speaking family, friends, and formal education in Spanish could explain their dominance in English. Participant 2, while having Spanish-speaking family and friends, did not report any formal education in Spanish, possibly leading to their slight dominance in English. Participants 3 and 4's reported extended time in Spanish-language formal education as well as in Spanish-language communities within the U.S. correspond to their more balanced scores. Participant 5's extended time in Mexico, which included some formal education in Spanish, and exclusively Spanish-speaking family correlates with their more "balanced" bilingualism as well.

3.4.2 Acoustic Analysis

The recordings were analyzed with Praat software. 255 sentences, or intervals, were first segmented and annotated to a TextGrid and then run through a script which extracted the F0 average, F0 minimum and F0 maximum. 28 intervals were left out due to hesitations or false starts and seven were left out for technical issues that affected pitch, such as frication, leaving 220 intervals to be used for analysis. Ten intervals were manually corrected due to a false recording of pitch height or average and 14 were manually corrected due to an error in which pitch was being recorded by the software for a voiceless sound (which has no pitch). Eight were also manually corrected due to the presence of creaky voice, which was usually present at the end of an interval. For these, the original extractions were kept, but the manually corrected extractions from which the creaky voice was left out were also recorded. **Image 1** represents an errorless interval which was extracted and analyzed for mean, minimum, and maximum pitch.

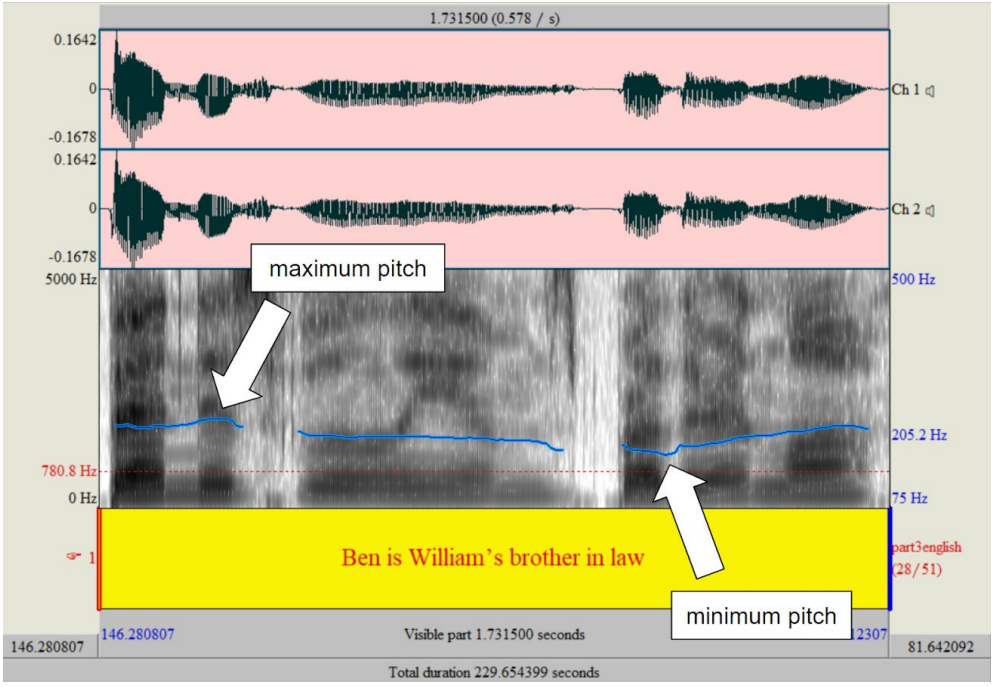

Image 1: *Example of interval in Praat. Blue line represents pitch.*

4. Results

Table 3: Fundamental Frequency Data (Hz)

Participant	Language	Mean F0 Average		Mean F0 Minimum	Mean F0 Maximum	
1	English	170.94		108.60	218.24	
	Spanish	194.12		125.09	239.58	
2	English	173.07		113.97	204.02	
	Spanish	187.43		105.94	233.33	
3	English	167.88		102.99	201.78	
	Spanish	169.98		107.41	218.57	
4	English	218.62		121.28	269.15	
	Spanish	228.77		149.24	269.84	
5		**Creaky Voice Included**	**Creaky Voice Excluded**	**(does not affect min)**	**Creaky Voice Included**	**Creaky Voice Excluded**
	English	128.46	125.78	107.77	171.76	144.60
	Spanish	126.94	122.05	96.49	208.14	149.37

Table 3: Fundamental Frequency Data (Hz), *continued*

Participant	Language	Range F0 Average		Range F0 Minimum	Range F0 Maximum	
1	English	133.80-199.91		66.82-161.01	182.91-322.83	
	Spanish	163.39-225.06		76.26-180.89	203.17-318.59	
2	English	147.59-198.63		78.58-173.29	191.38-228.08	
	Spanish	158.25-217.08		68.66-168.66	197.29-272.62	
3	English	144.94-206.38		73.29-171.05	171.68-298.32	
	Spanish	143.10-191.24		70.05-166.53	187.02-320.69	
4	English	184.91-256.00		74.59-213.48	238.06-340.90	
	Spanish	197.84-244.23		75.71-227.41	235.11-311.24	
5		**Creaky**	**Creaky**	**(does not affect min)**	**Creaky**	**Creaky**

		Voice Included	**Voice Excluded**		**Voice Included**	**Voice Excluded**
	English	120.04-145.07	119.46-132.91	91.07-114.57	136.27-323.83	132.28-202.07
	Spanish	116.97-182.56	116.05-135.04	75.16-112.55	130.07-508.54	130.04-267.03

After recording the mean and range of the pitch of each sentence, the mean for each language's average, minimum, and maximum F0 for each participant was found and included in the table above. For participant 1, three intervals from their English portion were removed due to false starts and/or hesitations. Five intervals were manually corrected due to an error in which pitch was recorded for voiceless sounds. Their English mean F0 average is 170.94 Hz with a range of 133.80-199.91 Hz. The mean F0 minimum is 108.60 Hz with a range of 66.82-161.01 Hz and their mean F0 maximum is 218.24 Hz with a range of 182.91-322.83 Hz. From their Spanish portion, one interval was removed due to a false start and/or hesitation. Three intervals were removed for errors during the recording that affected the measure of pitch. Two intervals were manually corrected due to an error in which pitch was recorded for voiceless sounds. Their Spanish mean F0 average is 194.12 Hz with a range of 163.39-225.06 Hz and the mean F0 minimum is 125.09 Hz with a range of 76.26-180.89 Hz and the mean F0 maximum is 239.58 Hz with a range of 203.17-318.59 Hz. It is clear that participant 1's F0 is lower in English than in their Spanish. Their mean F0 average in English is 23.18 Hz lower than that of Spanish, their mean F0 minimum in English is 16.49 Hz lower than that of Spanish, and their mean F0 maximum in English is 21.34 Hz lower than that of Spanish.

For participant 2's English portion, two intervals were removed due to false start and/or hesitation. One interval was removed due to an error during the recording that affected the measure of pitch. The mean F0 average is 173.07 Hz with a range of 147.59-198.63 Hz with a

mean F0 minimum of 113.97 Hz and a range of 78.58-173.29 Hz and a mean F0 maximum of 204.02 Hz with a range of 191.38-228.08 Hz. For their Spanish portion, two intervals were removed due to false starts and/or hesitations. One interval was removed due to an error during the recording that affected the measure of pitch. Four intervals were manually corrected, two due to false pitch height documentation and two due to an error in which pitch was recorded for voiceless sounds. The mean F0 average is 187.43 Hz with a range of 158.25-217.08 Hz with a mean F0 minimum of 105.94 Hz which has a range of 68.66-168.66 Hz and a mean F0 maximum of 233.33 Hz with a range of 197.29-272.62 Hz. The differences between participant 2's F0 in English and Spanish is notable. Their mean F0 average in English is 14.36 Hz lower than that of Spanish, their mean F0 minimum in English is 8.03 Hz higher than that of Spanish, and their mean F0 maximum is 29.31 Hz lower than that of Spanish. While their average and maximum pitch is lower in English than Spanish, their minimum pitch is higher.

For participant 3's English portion, two intervals were removed due to false starts and/or hesitation. Three intervals were manually corrected due to an error in which pitch was recorded for voiceless sounds. The mean F0 average is 167.88 Hz with a range of 144.94-206.38 Hz and the mean F0 minimum is 201.99 Hz with a range of 73.29-171.05 Hz and the mean F0 maximum is 201.78 Hz with a range of 171.68-298.32 Hz. For their Spanish portion, five intervals were removed due to false starts and/or hesitations. Two intervals were manually corrected, one due to an error in the pitch height documentation and one due to an error in which pitch was recorded for a voiceless sound. The mean F0 average is 169.98 Hz with a range of 143.10-191.24 Hz and the mean F0 minimum is 107.41 Hz with a range of 70.05-166.53 Hz and the mean F0 maximum is 218.57 Hz with a range of 187.02-320.69 Hz for the maximum F0. The F0 for participant 3's Spanish and English is much closer together than participants 1 and 2. Their mean F0 average in English is 2.1 Hz lower than that of Spanish,

their mean F0 minimum in English is 4.42 Hz lower than that of Spanish, and their mean F0 maximum in English is 16.78 Hz lower than that of Spanish.

For participant 4's English portion, six intervals were removed due to false starts and/or hesitations. Two intervals were removed due to intonational stress. One interval was manually corrected due to an error in which pitch was recorded for a voiceless sound. The mean F0 average is 218.62 Hz with a range of 184.91-256.00 Hz. The mean F0 minimum is121.28 Hz with a range of 74.59-213.48 Hz and the mean F0 maximum is 269.15 Hz with a range of 238.06-340.90 Hz. For their Spanish portion, one interval was removed due to a false start and/or hesitation. The mean F0 average is 228.77 Hz with a range of 197.84-244.23 Hz and the mean F0 minimum is 149.24 Hz with a minimum F0 range of 75.71-227.41 Hz and the mean F0 maximum is 269.84 Hz with a range of 235.11-311.24 Hz. The differences in participant 5's F0 is notable as well. While their average and minimum pitch differences vary greatly, there is hardly a difference in their maximum F0. Their mean F0 average in English is 10.15 Hz lower than that of Spanish, their mean F0 minimum in English is 27.96 Hz lower than that of Spanish, and their mean F0 maximum in English is 0.69 Hz lower than that of Spanish.

For participant 5's English portion, four intervals were removed due to hesitations and/or false starts. Two intervals were manually corrected, one due an error in the documentation of the minimum F0, and one due to a drop in pitch at the end of the utterance. Four intervals were manually corrected but documented separately due to creaky voice, with the original mean and maximum F0 still documented as well. With creaky voice included, the mean F0 average is 128.46 Hz with a range of 120.04-145.07 Hz and the mean F0 minimum is 107.77 Hz with a minimum F0 range of 91.07-114.57 Hz and a mean F0 maximum of 171.76 Hz with a maximum F0 range of 136.27-323.83 Hz. With creaky voice excluded, the mean F0 average is 125.78 Hz with a range of 119.46-132.91 Hz and the mean F0 minimum is 107.77 Hz with the same

minimum F0 range and a mean F0 maximum of 144.60 Hz with a maximum F0 range of 132.28-202.07 Hz. Participant 5's F0 differences are quite unique. With creaky voice included, their mean F0 average in English is 1.52 Hz higher than that of Spanish, their mean F0 minimum in English is 11.28 Hz higher than that of Spanish, and their mean F0 maximum is 36.38 Hz lower than that of Spanish.

For Participant 5's Spanish portion, two intervals were removed due to hesitations and/or false starts. Two intervals were manually corrected due to an error in the documentation of the maximum F0. Three intervals were manually corrected due to an error in which pitch was recorded for voiceless sounds. Two of these intervals included creaky voice, as well as two other intervals which did not include the voiceless sound error. The pitch for the four intervals with creaky voice were documented both including and excluding the creaky voice. With creaky voice included, the mean F0 average is 126.94 Hz with a range of 116.97-182.56 Hz and the mean F0 minimum is 96.49 Hz with a minimum F0 range of 75.16-112.55 Hz and a mean F0 maximum of 208.14 Hz with a maximum F0 range of 130.07-508.54 Hz. With creaky voice omitted, the mean F0 average is 122.05 Hz with a range of 116.05-135.04 Hz and the mean F0 minimum is 96.49 Hz with the same minimum F0 range and a mean F0 maximum of 149.37 Hz with a maximum F0 range of 130.04-267.03 Hz. With creaky voice excluded, their mean F0 maximum in English is 3.75 Hz higher than that of Spanish, their mean F0 minimum is not affected and is still 11.28 Hz higher in English compared to Spanish, and their mean F0 maximum in English is 4.77 Hz lower than that of Spanish.

Three dependent-samples or paired t-tests were used to compare the pitch between English and Spanish for all participants. For the t-test, the data including creaky voice for participant 5 was used as it is a more accurate representation of the speech of that participant than the data excluding creaky voice. The first paired t-test compared the mean F0 of English

and Spanish for all participants (t=2.19, p=0.09), where no significant difference was found (English = 171.79 Hz, Spanish = 181.45 Hz). The second paired t-test compared the minimum F0 of English and Spanish for all participants (t=0.80, p=0.47), where no significant difference was found (English = 110.92 Hz, Spanish = 116.83 Hz). The third paired t-test compared the maximum F0 of English and Spanish for all participants (t=3.45, p=0.03), with English associated with a lower maximum pitch than Spanish (English = 212.99 Hz, Spanish = 233.89 Hz). This data is summarized in **Table 4**.

Table 4: Paired T-Tests for Mean, Min, and Max F0

	Mean F0	Minimum F0	Maximum F0
P-Value	0.09	0.47	0.03
T-Value	2.19	0.80	3.45
Statistically significant?	No	No	Yes

To sum up, while there is no significant difference for either the mean or minimum pitch between English and Spanish, there is a significant difference for the maximum pitch. That is, heritage speakers do not present differences in their English versus Spanish as observed in their mean and minimum F0, but there is evidence that heritage speakers of Spanish present differences in their pitch in English versus Spanish as observed in their maximum F0. Due to the limitations of this study, including having a small sample of the population and a limited amount of data, further studies are required to confirm these observations.

Additionally, five unpaired or independent-samples t-tests were used to compare the mean F0 of each participant's English to that of their Spanish. The t-tests compared all of the average F0s of the participant's intervals in English to those in Spanish. The minimum and

maximum values for each interval were not used for this analysis because the t-test requires mean values and not ranges. These supplemental tests were run to determine if the English and Spanish of each heritage speaker individually had a significantly different mean pitch in English compared to Spanish, even though the mean pitch for each language across the entire sample population was found to not have a significant difference. The first t-test was used to check the difference in Participant 1's mean F0, t=-4.44, p=0.0001, with English associated with a lower mean pitch than Spanish (English = 170.94 Hz, Spanish = 194.12 Hz). The second t-test was used to check Participant 2's mean F0, t=-3.26, p=0.0022, with English associated with a lower mean pitch than Spanish (English = 173.07 Hz, Spanish = 187.43 Hz). The third t-test was used to check Participant 3's mean F0, t=-0.55, p=0.5881, but no significant difference was found (English = 167.88 Hz, Spanish = 169.98 Hz). The fourth t-test was used to check Participant 4's mean F0, t=-2.18, p=0.0351, with English associated with a lower mean pitch than Spanish (English = 218.62 Hz, Spanish = 228.77 Hz). The fifth t-test was used to check Participant 5's mean F0, t=0.46, p=0.6470, but no significant difference was found (English = 128.46 Hz, Spanish = 126.94 Hz). This data is summarized in **Table 5**.

Table 5: Unpaired T-tests for Each Participant's F0 Average

Participant	P-Value	T-Value	Statistically significant?	Type of Acquisition	Dominance Score
1	0.000067	-4.43654	Yes - English lower	Simultaneous	77.74
2	0.002206	-3.26113	Yes - English lower	Simultaneous	48.038
3	0.588061	-0.54575	No	Successive	7.462
4	0.035126	-2.17731	Yes - English lower	Simultaneous	16.44
5	0.646979	0.46218	No	Successive	-1.444

Overall, participants 1, 2, and 4 have significantly lower average F0s between English and Spanish and participants 3 and 5 do not. If these results are compared to those in **Table 2**, there seems to be a correlation between dominance scores and significant difference in mean pitch. Participants 3 and 5 had dominance scores of 7.462 and -1.444 respectively, while participants 1, 2, and 4 had dominance scores of 77.74, 48.038, and 16.44 respectively. Participants 3 and 5 had dominance scores closer to zero, which would indicate more "balanced" bilingualism, and participants 1, 2, and 4 had dominance scores farther from zero, which would indicate more dominance in English as compared to Spanish. Furthermore, participants 1, 2, and 4 began learning English at 3 years of age or younger (since birth, age 3, and age 3, respectively), and thus acquired English and Spanish simultaneously, whereas participants 3 and 5 began learning English a few years later (age 5 and age 8, respectively), meaning they acquired Spanish and English successively. This data is also included in **Table 5**.

5. Conclusion

This paper explores whether fundamental frequency varies in heritage speakers of Spanish by the language being spoken in terms of mean, minimum, and maximum pitch. While a diverse amount of methods were considered for this study, a contextualized image description task was ultimately chosen, as it limits the inconsistency of the utterances produced in a task such as an open-ended interview while preventing the unnatural speech that can occur with a reading task. The utterances produced by the participants in this study were analyzed for mean, minimum, and maximum pitch.

It was concluded that when data across all participants is compared, heritage speakers of Spanish do not present significant differences in their pitch in English vs. Spanish as

observed in their mean or minimum F0. However, they do present differences in their pitch as observed in their maximum F0 in that English is associated with a lower maximum F0 than Spanish. It was also concluded that when the means were compared individually, three of the five participants had significant differences in their mean pitch whereas two of them did not, which correlated to the age at which they began to learn English as well as their dominance score on the Bilingual Language Profile. Those who had significant differences in their mean pitch learned English and Spanish simultaneously and had higher dominance scores in English, where those who did not have significant differences in their mean pitch learned Spanish and English successively and had dominance scores closer to zero, which indicates “balanced” dominance in their languages. It’s important to note that the language dominance and experience varies greatly within the community of HSS, and that while language questionnaires such as the BLP do take proficiency into account, language dominance is not equal to language proficiency.

Even though further studies are required to confirm these findings, it’s possible that the HSS who learned English and Spanish simultaneously have more dominance in English than those who learned Spanish and English successively because they began learning at a younger age. It also could be argued that the simultaneous learners are able to keep their languages more separate than successive learners whose languages may influence each other, which may be why simultaneous learners have a significant difference in the pitch of their two languages and the successive learners do not. Overall, this correlation may be due to the simultaneous learners’ ability to separate their languages more effectively, while successive learners may have relied on their first language to learn their second resulting in the two languages influencing each other and therefore becoming more similar.

It would be necessary in future research to expand the sample size of the population and to collect more data. Expanding sample size should not only include the number of participants, but also the age, the place of origin of the Spanish-speaking family, and the gender of the participants should be diversified. It would be interesting to look at interrogative forms in addition to variations of declarative sentences. It may also be useful to compare heritage speakers of other non-tonal languages to see if these findings can be applied to languages other than English and/or Spanish.

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